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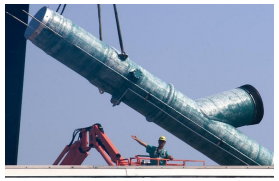
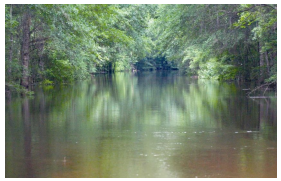
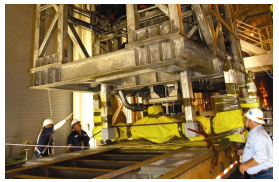
Uses, Alternatives and Control Measures for Beryllium

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The findings and conclusions in this presentation are those of the author and do not necessarily represent the views of WSRC.

The speaker, as a Department of Energy contractor employee, does not speak for or represent DOE or any other federal agency.

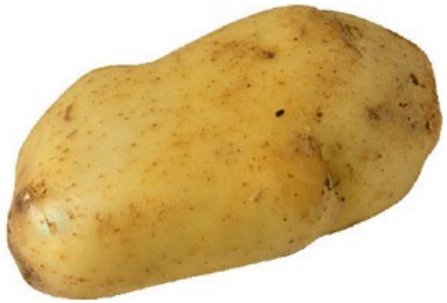
Overview

- **Beryllium Uses**
  - **Metal, alloy, oxide**
- **Why alternatives?**
  - **Hazards**
  - **Occupational exposure limits**
  - **Sampling and analysis issues**
- **What alternatives?**
- **Control measures**
  - **Engineering**
  - **Administrative**
  - **PPE**
  - **Monitoring**
- **The Be Health and Safety Committee (BHSC)**

(Source: ATSDR web site, www.atsdr.cdc.gov)

Beryllium Is Found In …

- **Foodstuffs (μg per kg fresh weight – ATSDR 2002)**
  - **Milk (0.2)**
  - **Potatoes (59)**
  - **Crisp bread (112)**
  - **Kidney beans (2200)**
- **Soils (up to 15,000 μg/kg – USGS)**
- **Coal (0.2% - ATSDR 2002)**
- **Orchard Leaves (26 μg/kg – ATSDR 2002)**
- **Cigarettes (up to 0.74 μg/cigarette – ATSDR 2002)**
- **Minerals such as bertrandite, beryl, aquamarine, emerald**



(aggie-horticulture.tamu.edu)

Beryllium Properties

- **Lightweight**
- **High melting point (1287°C)**
- **Thermal conductivity**
- **Moderator**
- **Neutron reflector**
- **Relatively transparent to X-Rays**

Uses for Beryllium Products (20-100% Be)

- Satellites and spacecraft
- Guidance systems (military and commercial)
- Brake parts (automotive, aircraft)
- Nuclear weapons (neutron reflector)
- X-Ray windows
- Optical instruments
- High-end audio
- Sports equipment

(Fermilab Web site, www-esh.fnal.gov)

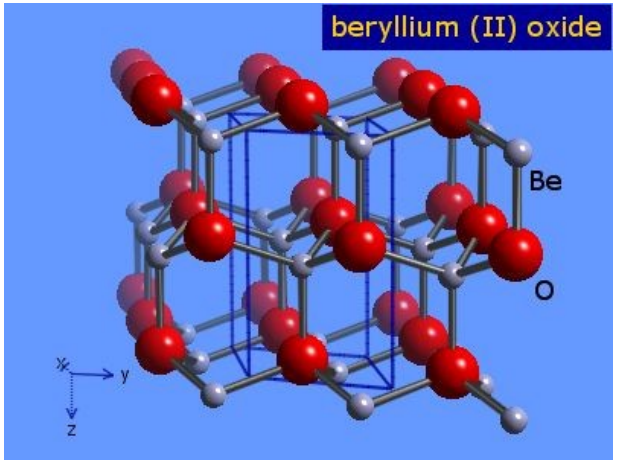
Beryllium Alloys

- **Copper-beryllium (CuBe)**
  - **Resistant to metal fatigue failure**
  - **Resistant to corrosion**
  - **Rotary-dial telephone springs**
  - **Non-sparking tools**
- **Aluminum-beryllium (AlBeMet® - Brush-Wellman)**
  - **Resistant to corrosion**
- **Nickel-beryllium**
- **Uses for alloys:**
  - **Fire control sprinkler heads**
  - **Aircraft landing gear bushings**
  - **Current-carrying springs**
  - **Electromagnetic shielding**

(CuBe at Brush-Wellman Elmore, OH, plant, www.brushelmore.com)

Beryllium Oxide

- Semiconductor parts
- Integrated circuits
- Good thermal conductivity
- Good electrical insulator
- Nuclear reactors
  - Moderator
  - Neutron reflector



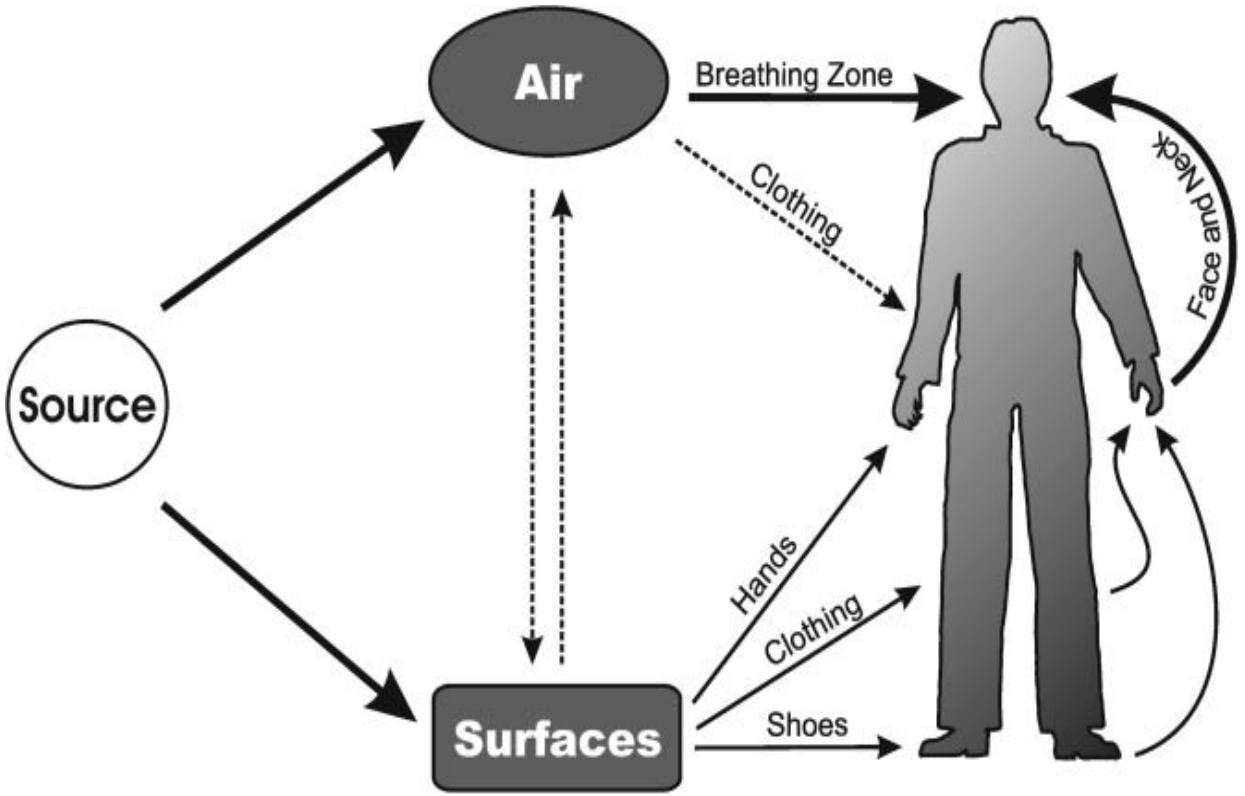
(Source:
WebElements™,
www.webelements.com
Used with permission)

So Why Would We Want Alternatives?

Exposure to particles of beryllium metal, alloys, and oxide can lead to:

- **Beryllium Sensitization (BeS)**
  - **Immune system response in percentage of those exposed**
  - **Detected by Be Lymphocyte Proliferation Test (BeLPT)**
    - **BeLPT used by DOE but not necessarily endorsed by branches of the Armed Forces**
    - **Issues with sensitivity and specificity**
- **Chronic Beryllium Disease (CBD)**
  - **Percentage of sensitized individuals**
  - **Particulate lodged in lung, cannot be expelled**
  - **Leads to lesions (granulomas)**
  - **Medically diagnosed (bronchioalveolar lavage or BAL)**
  - **Treatable but currently not curable**

Beryllium Exposure-Pathway Model



Day et al, *Ann Occup Hyg* 51:67-80 (2007)

Characterizing the Risk

- **Historically understood to be mainly inhalation exposure risk**
- **Dermal exposure now believed to be a possible factor**
- **Risk appears higher for some beryllium manufacturing operations than for others – some examples:**
  - **Machinists**
  - **Rod and wire production**
  - **Lapping**
- **Number of beryllium particles may be as important as total beryllium mass**

Be Occupational Exposure Limits

- **ACGIH® Threshold Limit Value (TLV®) and OSHA Permissible Exposure Limit (PEL)**
  - **ACGIH® TLV® and OSHA PEL: 2 μg/m³ (8-hour time-weighted average or TWA)**
  - **Same limit in Austria, Spain, France, Sweden, U.K., and Ontario**
    - **Denmark: 1 μg/m³**
  - **Originally proposed in 1949 from Atomic Energy Commission studies**
  - **ACGIH® adopted TLV® in 1959 for beryllium; applied to "beryllium and compounds" in 1986**
- **Short-term exposure limits (STEL)**
  - **Maximum exposure for any 15-minute period**
  - **U.S.: 5 μg/m³**
  - **Austria: 8 μg/m³**
  - **Denmark, Hungary: 2 μg/m³**

(Source: Lawrence Livermore National Lab)

Be OEL's – Recent History

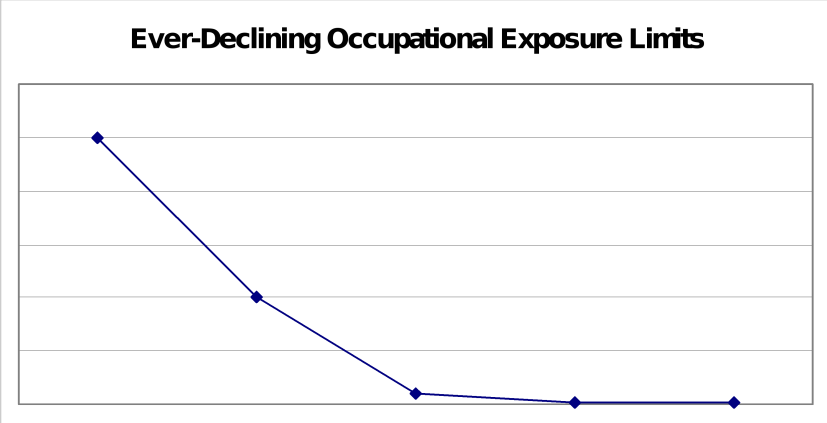
1999-2002:

- **1999: ACGIH® proposed a TLV-TWA of 0.2 μg/m³; not adopted**
- **2000: DOE Beryllium Rule (10 CFR 850) took effect**
  - **0.2 μg/m³ TLV-TWA along with surface limits**
  - **Has led to large amounts of surface wipes**
- **2002: OSHA begins process of revising PEL**
  - **Request for information: 67 FR 70707**
  - **SBREFA Report has been delayed several times, but appears likely to be complete in 2008**

Be OEL's – Recent History (2)

2005-Present:

- **2005: ACGIH® Notice of Intended Change (NIC) to 0.02 μg/m³ TLV-TWA; not adopted**
- **2006**
  - **ACGIH® NIC for 0.05 μg/m³ TLV-TWA and STEL of 0.2 μg/m³**
  - **California OSHA adopts PEL of 0.2 μg/m³ (same as DOE action level)**
  - **Quebec adopts PEL of 0.15 μg/m³**
- **2007**
  - **2006 ACGIH® NIC carried over**
- **2008**
  - **2006 ACGIH® NIC carried over**



(Illustration only)

Alternatives to Beryllium

- **Silicon carbide (satellite mirrors)**
  - **Research funded by Missile Defense Agency**
- **R&D Efforts to Identify Alternatives**
  - **Navy SBIR grant (FY05) for alternative to CuBe**

In short, not many alternatives (yet), so we need to be able to work with beryllium safely …

Control Measures - Engineering

- Enclosures
- Ventilation
- Prevent re-suspension of particulate
  - No dry sweeping
  - Dedicated HEPA vacuums
- Minimize activities that may abrade or cut skin

Control Measures - Administrative

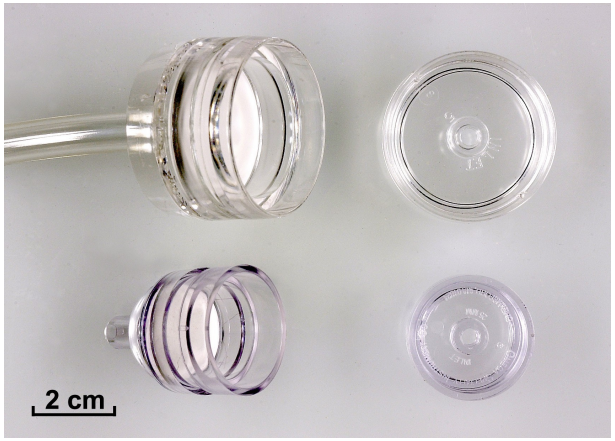
- Demarcate beryllium work areas (signs, markings, or barriers)
- Train workers in contamination control
- Do not use personal items that may become contaminated and are not readily cleaned
- Do not eat, drink, smoke, or apply cosmetics
- Encourage use of Human Performance tools
  - Peer checking, self-checking, procedure adherence, technical inquisitiveness, personal accountability

Control Measures - PPE

- **Protective clothing as appropriate**
  - **May include coveralls, gloves, safety shoes or shoe covers, respirators**
- **Cover skin wounds or abrasions to prevent Be contamination**
- **Prevent skin contact with contaminated surfaces**
- **Provide change rooms**
- **Provide showers where appropriate**
  - **Shower after removing PPE, before donning personal clothing**

Control Measures – Workplace Monitoring

- **Breathing zone sampling**
  - **Lapel monitor with 2 L/min pump**
  - **U.S.: 25 mm or 37 mm closed face cassette (CFC)**
  - **Europe: IOM sampler (ISO inhalable sampling convention)**
- **Surface wipes**
  - **Used by DOE for housekeeping and release of materials from one area to another**
  - **Also used in Quebec**
  - **No requirement or standard outside of DOE**
- **Analysis**
  - **Fixed-site laboratory techniques: ICP-AES, ICP-MS, GFAA**
  - **Molecular fluorescence (field deployable)**
- **Challenges in both sampling and analysis areas (topic for another presentation)**



(Source: Ashley, Brisson, and Jahn, *Standardization Issues in Beryllium Sampling and Analysis*, presented at Pittcon 2006)

The Be Health and Safety Committee

- **Ad hoc group**
- **Representatives primarily from DOE, DOD, AWE**
- **Also representatives from NIOSH, OSHA, Brush-Wellman, and others**
- **Multi-disciplinary (IH, chemistry, medical/epidemiological, operations)**
- **Mission (www.BeHSC.com): “To promote the safe use of beryllium and prevent chronic beryllium disease and other adverse health effects in the workplace.”**
- **Subcommittees: CBD Prevention, Research Needs, Technical Practices, Medical/Epidemiological, Sampling and Analysis (SAS), Data Reporting Task Force**

Major BHSC Activities

- **Information exchange**
  - **Two meetings per year**
  - **Conference calls**
- **White papers**
- **Standards on sampling and analysis techniques**
- **Professional development course (PDC) on surface sampling at AIHA conference (5/31/08)**
- **Third International Symposium on Beryllium Particulates and Their Detection, 11/18-19/08, Albuquerque, NM**

Credits

- **“Controlling Exposure in the Beryllium Work Environment”, Be Health and Safety Committee, 2007**
- **Hoover M, NIOSH, “Beryllium Properties and Uses”, International Beryllium Conference, Montreal, March 8, 2005**
- **Kreiss K et al., *Ann Rev Public Health* 28:259-277 (2007)**
- **www.findarticles.com**
- **www.navysbir.com**
- **www.speclab.com**

For More Information …

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